EMB190 Alerting Issues – Loss/degradation of GPS

1. Initiating Condition: Poor GPS satellite availability or geometry leading to decreased GPS signal integrity

Type	Alert or cue	Threshold for alert or cue to be presented	Confusion regarding alert or cue	Other issues with regard to alert or cue	When alert is inhibited/suppressed or when cue is masked	How alert or cue is terminated
Visual Alerts	Text messages "UNABLE RNP NEXT WPT," "GPS RAIM UNAVAILABLE," and "UNABLE RNP" on FMS scratchpad	EPU>RNP	Meaning of text can be unclear	Text messages on FMS scratchpad can be inadequately salient. Also, once cleared by pilot action, they may not be re-displayed		When EPU<RNP
	Amber "DGRAD" alerting text on PFD	EPU>RNP				When EPU<RNP
	Amber "MSG" alerting text on PFD	Driven by FMS scratchpad messages				When scratchpad has been cleared using the CLR key on the keypad.
Aural Alerts	None					
Tactile Alerts	None					
Visual Cues	Displayed EPU (Estimated Position Uncertainty) value greater than displayed RNP value on FMC Progress Page 1		Meaning of text can be unclear	Requires effortful selection of the appropriate page and comparison of the two numbers		When EPU<RNP
Aural Cues	None					
Tactile/ Somatic Cues	None					

EMB190 Alerting Issues – Loss/degradation of GPS

1. Initiating Condition: Poor GPS satellite availability or geometry leading to decreased GPS signal integrity – Cont.

Expected Pilot Response(s)

- Return to ground-based navigation, if any, as directed by the NNP
- During RNAV or RNAV/RNP approach, execute missed approach

How does pilot know condition is resolved/recovered?

- Lookup of FMS page displaying EPU/RNP; inspection of EPU/RNP values.

Issues with regard to multiple concurrent non-normal conditions

- Loss of terrain clearance warning
- False terrain clearance warning
- Loss of separation from air traffic (ADS or NextGen navigation/surveillance)

EMB190 Alerting Issues – Loss/degradation of GPS

2. Initiating Condition: Intentional spoofing (intentional introduction of false position into the GPS receiver) leading to false position input from GPS to the FMS

Type	Alert or cue	Threshold for alert or cue to be presented	Confusion regarding alert or cue	Other issues with regard to alert or cue	When alert is inhibited/ suppressed or when cue is masked	How alert or cue is terminated
Visual Alerts	FMS CDU scratchpad text message "CHECK (IRS1 or IRS 2) POSITION"	GPS-derived FMS position differs from IRS and/or Radio positions by more than 10 miles	Potentially very confusing because the text message suggests an error in the IRS or Radio positions, while in fact the error is in the GPS position.	Text messages and alerts on FMS scratchpad can be inadequately salient. Also, once cleared they may not be re-displayed. Alerting and cueing depends on continued operation of multi-mode navigation, with at least inertial position inputs. The alerting threshold for this alert (10 miles) likely far exceeds RNP values for all but Oceanic procedural separation, so these alerts may be of limited safety value in current RNP or future Next Gen operations.		When position difference has been reduced to within limits or the inaccurate position source has been manually deselected from the FMS solution
	Amber "MSG" alerting text on PFD	Driven by FMS scratchpad message				When scratchpad has been cleared using the CLR key on the keypad.
Aural Alerts	None					
Tactile Alerts	None					

EMB190 Alerting Issues – Loss/degradation of GPS

2. Initiating Condition: Intentional spoofing (intentional introduction of false position into the GPS receiver) leading to false position input from GPS to the FMS – Cont.

Type	Alert or cue	Threshold for alert or cue to be presented	Confusion regarding alert or cue	Other issues with regard to alert or cue	When alert is inhibited/ suppressed or when cue is masked	How alert or cue is terminated
Visual Cues	Map shift is likely when the spoofed position is introduced, because the FMS position equals the GPS position (unless the system detects a degraded GPS solution or the pilots manually deselect GPS input to the FMS)	Cause of the map shift will be unclear and it will not be evident whether the shift was to a more or less accurate position.	Only salient if the system makes a position change or correction while a pilot is looking at the MFD map display. The map shift may not be noticed, or if noticed In the absence of map shift and FMS text alerts there will be no alerting or cueing to false position unless the introduced false position is more than 10 miles from the actual position.			
	On the FMS CDU Position Source page, the displayed latitude/longitude values for the various navigation sources (GPS, IRS, Radio) show discrepancies.		Not salient because display of the page requires manual selection and effortful comparison of several latitude/longitude values			
Aural Cues	None					
Tactile/ Somatic Cues	None					

<u>Expected Pilot Response(s)</u>

- Verify position using alternative means (e.g. radar, DME)
- Identify false information
- Eliminate source of false information from the position solution

EMB190 Alerting Issues – Loss/degradation of GPS

2. Initiating Condition: Intentional spoofing (intentional introduction of false position into the GPS receiver) leading to false position input from GPS to the FMS – Cont.

Possible sources of confusion with regard to pilot response(s)

- Without effortful investigation it may not be clear to the pilot which of the navigation sources is/are providing the false position; also, because of the normally high accuracy of GPS pilots tend to believe its information and downplay the other sources. This is particularly the case because the FMS are programmed to heavily weight the GPS position in calculating the FMS position solution (in this case defaulting to 100 percent GPS position), because of the normal great accuracy of GPS. As a result, the FMS position may drift or shift into a false position that may appear, to the pilots, to be a malfunction of the IRS or Radio position sources.

How does pilot know condition is resolved/recovered?

- Verifying position after reverting to alternative navigation

Issues with regard to multiple concurrent non-normal conditions

- Loss of terrain clearance warning
- False terrain clearance warning
- Loss of separation from air traffic (ADS or NextGen navigation/surveillance)